The Effects of Exploitation on the Arctic Charr Population of the Sylvia Grinnell River, Northwest Territories

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by

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ABSTRACT

KRISTOFFERSON, A.H., and R.D. SOPUCK. 1983. The effects of exploitation on the Arctic charr population of the Sylvia Grinnell River, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 1721: v + 35 p.

A creel census and biological investigation of the Arctic charr (Salvelinus alpinus) population of the Sylvia Grinnell River was conducted in July and August of 1976 and 1977. Four hundred and twenty-seven anglers interviewed in 1976 retained a total of 212 charr and 374 interviewed in 1977 retained a total of 379 charr. Estimates suggest that the subsistence gillnet fishery took at least 2 282 charr in 1977 and snagging took at least 4 923 charr in 1977. The size and age composition of the stock has declined considerably since earlier studies in 1948, 1950, 1951 and 1958. Charr larger than 55 cm were rarely encountered during this study. Observations of the 1982 fishery indicate that the stock has not yet recovered. Present fishing effort is probably sufficient to prevent the recovery of the stock. Recommendations include closure of a portion of the river below the falls to all fishing since charr congregate there in large numbers and are very vulnerable to capture. Such a closure would eliminate snagging, a practice which harvests large numbers of small charr.

Key words: age composition; angling; catching methods; fishing mortality; monitoring; population structure; Salvelinus alpinus (L); size distribution.

RESIME

KRISTOFFERSON, A.H., and R.D. SOPUCK. 1983. The effects of exploitation on the Arctic charr population of the Sylvia Grinnell River, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 1721: v + 35 p.

En juillet et août 1976 et 1977, on a effectué un relevé des prises d'ombles chevaliers (Salvelinus alpinus) ainsi qu'une étude biologique des stocks d'ombles de la rivière Sylvia Grinnell. Les 427 pêcheurs sportifs interviewés en 1976 ont gardé un total de 212 ombles, tandis que les 374 pêcheurs interviewés en 1977 ont gardé 379 ombles. On estime que la pêche de subsistance aux filets maillants a récolté 2 282 ombles en 1977 et qu'au moins 4 923 ombles ont été pris à l'hameçon nu en 1977. La taille et l'âge moyens des poissons ont baissé considérablement depuis les études de 1948, 1950, 1951 et 1958; lors de la présente étude, les ombles de plus de 55 cm étaient rares. Une étude des pêches de 1982 a révélé que les stocks d'ombles n'étaient pas encore rétablis. La pêche actuelle est probablement suffisante pour empêcher ce rétablissement. Cet ouvrage recommande d'interdire la pêche dans la partie de la rivière, en aval des chutes, où les poissons se rassemblent en grand nombre et sont très faciles à prendre. La prise d'une telle mesure éliminerait la pêche à l'hameçon nu, méthode qui récolte un grandnombre de petits ombles.

Mots-clés: moyenne d'âge; pêche sportive; méthodes de pêche; mortalité due à la pêche; contrôle; structure de la population; Salvelinus alpinus (L); distribution des tailles.

INTRODUCTION

The Arctic charr (Salvelinus alpinus (L.)) of the Sylvia Grinnell River on Baffin Island have been subject to varying degrees of exploitation by man. Inuit have traditionally fished for charr in the lower reaches of this river where it empties into Frobisher Bay (Hunter 1976). Commercial fishing using gillnets was initiated by the Shaw Steamship Company in 1947 and continued in 1948 and 1950 (Hunter 1976). Fishing was done in the estuary adjacent to the mouth of the river (Grainger 1953). Some of the older residents of Frobisher Bay claim that this fishery removed large quantities of charr each year. During 1951-57 charr were taken by subsistence and recreational fisheries (Hunter 1976). In 1958 the Department of Indian Affairs and Northern Development reestablished the commercial fishery for charr with an annual harvest objective of 4 500 kg (Hunter 1976). During 1958-62 fishing was good, with the quota being taken each year in only a few days (Hunter 1963). However, declining catch for effort and small fish size followed and the commercial fishery ceased operating after 1966 (Hunter 1976). Since then only the subsistence and recreational fisheries have persisted.

There are indications that Arctic charr in the Sylvia Grinnell River have been overexploited (Scott and Crossman 1973; Hunter 1976). Local residents and anglers in Frobisher Bay report that their catch consists mostly of small fish and return for fishing effort is poor. The present study was undertaken during the summers of 1976 and 1977 to assess the status of the Arctic charr stock in the river. Results are compared with those of previous studies by Grainger (1953) and Hunter (1958). Changes in the charr population over the period of study are discussed and recommendations are made for future use of this valuable resource.

MATERIALS AND METHODS

STUDY AREA

The Sylvia Grinnell River empties into Frobisher Bay at 63°44'N, 68°34'W (Fig. 1), about 2 km west of the town of Frobisher Bay. The river drains Sylvia Grinnell Lake, located approximately 70 km upstream. Anadromous Arctic charr are believed to overwinter in this lake (Grainger 1953). The river flows over a series of falls and rapids just before it meets tidal waters in an upper area of Frobisher Bay (Fig. 2). The height of the falls varies from zero to about 3.7 m depending on the tide. These falls present an impassable barrier to charr ascending the river except during spring tides when the falls are inundated by the high water (Grainger 1953). Spring tides occur about twice a month. During low water the charr congregate below the falls and it is here that most of the fishing takes place.

CREEL CENSUS (SPORT FISHERY)

A creel census was conducted during the periods July 10 to August 28, 1976 and July 23 to August 15, 1977. Fishing sites (Fig. 2) were visited twice daily. As many anglers as possible were interviewed and their time spent fishing as well as the number of charr each one caught, kept and released was recorded. As many charr as possible from each angler's catch were sampled for biological data.

EXPERIMENTAL GILLNETTING

Experimental gillnets were used to capture Arctic charr at the mouth of the river. The gillnets were made up of five panels, each 22.9 m long and each of a different mesh size as follows: 38, 63, 89, 114 and 139 mm, stretched measure. Overnight sets (18 h) were made on August 20 and 21, 1976. The nets were set in the channel with one end fastened to the shoreline. An overnight set (24 h) was made on July 28, 1977 followed by daytime sets (6 h each) on August 2, 12 and 15. In addition, two overnight floating sets (20 h each) were made in Sylvia Grinnell Lake on August 7 and 8, 1977. Charr captured by this method were sampled for biological data.

SUBSISTENCE FISHERY

A subsistence gillnet fishery operated in the estuary during the 1976 and 1977 study periods. Some charr captured in this fishery on August 23 and 25, 1977 were sampled for biological data. Estimates of the daily catch were attempted in 1977 by observing the fishermen while they lifted their nets and removed the charr.

Another method of fishing was by snagging. Bare, weighted hooks were pulled through the water to hook fish. This was practised mostly by Inuit fishermen apparently for subsistence purposes. It was difficult to determine the number of charr taken by snagging since large numbers were captured in a short period of time by many individuals. Hence the number of charr recorded as having been taken by snagging is a minimum estimate.

BIOLOGICAL DATA

Charr were sampled for fork length (±1 mm) and round weight (±25 g). Saggital otoliths were removed and stored dry in envelopes for age determination. The otoliths were then immersed in a 3:1 solution of benzyl-benzoate and methyl salicylate in the laboratory prior to aging. Some otoliths were ground slightly on a fine carborundum stone to improve annulus clarity. Annuli were counted while the otoliths were observed with the aid of a compound microscope (X20). Ages were determined following Grainger (1953), counting the central core of the otolith as the first annulus. Sex and maturity were determined by gross examination of the gonads. Maturity stages are described in Appendix 13.

Age- and length-frequency histograms were constructed to display catch compositions from various gears. Ages of charr younger than 11 years that were taken in 1958 were not available. Hence an age-frequency distribution was

not constructed, although a catch curve for those 11 years and older was. Weight-length relationships were calculated using least squares regression analysis on logarithmic transformations of fork lengths and round weights.

The relationship is described as:

$$\text{Log}_{10} W = a + b\ (\text{Log}_{10} L)$$

Where: W = weight in grams
L = fork length in millimetres

Mean fork length at age was plotted from the data and growth rate was determined visually. Relative condition factor (K), a measure of the plumpness or robustness of the fish, was determined as:

$$K = \frac{W \times 10^5}{L^3}$$

Where: W = weight in grams
L = fork length in millimetres

Instantaneous total mortality (Z) was calculated from least squares regression lines fitted to the descending limb of catch curves. Only that portion of the curve that appeared linear was included in the analysis. Annual survival rates were calculated from Z. Instantaneous natural mortality (M) was assumed to be 0.13 after Hunter (1958). Instantaneous fishing mortality (F) was calculated from $Z = F + M$.

DATA ANALYSIS

Data were analyzed using a Hewlett Packard model 9810-A programmable calculator and an Amdahl 470/V7 Computer. Programs from the Statistical Analysis System (1979) were used for tests of significance and regression.

RESULTS AND DISCUSSION

STATUS OF THE STOCK

Length- and age-frequency distribution

Results of this study indicate that the composition of the anadromous Arctic charr stock in the Sylvia Grinnell River has changed significantly since 1948. Studies by Grainger (1953) show that charr larger than 55 cm (fork length) were relatively abundant in this system in 1948, 1950 and 1951. Data from Hunter (1958) reveal little change up to 1958. The present study indicates that charr larger than 55 cm had virtually disappeared from the stock by 1976/77 (Fig. 3). Correspondingly, a shift in the age composition of the charr stock is evident (Fig. 4). The gear used in each study are comparable. Grainger (1953) reports that gillnets of 25, 63, 102, 127, 139, 152 and 165 mm (stretched measure) were the primary method of capture. To a lesser extent hand nets, gaffs, jigs and minnow traps were used. Hunter (1958) used gillnets of 38, 51, 63, 89, 114 and 139 mm mesh size in 1958. During the present study samples were taken with similar sized gillnets (see MATERIALS AND METHODS) and by angling.

Johnson (1980) observed a bimodal length-frequency for anadromous Arctic charr taken in Creswell Bay in 1962. Subsequent examination of this population by Sekerak et al. (1976) and de March et al. (1978) revealed that charr in the larger mode were less frequent than in 1962. They attributed the decline in large charr to fishing pressure. Although bimodality in length of Arctic charr is not as pronounced in the Sylvia Grinnell River stock, there is some evidence of it in the 1948/50/51 and 1958 samples (Fig. 3). Johnson (1980) noted modal values of 35 cm and 55 cm in the Creswell Bay stock in 1962. A mode of 30 cm to 35 cm is evident in all three samples from the Sylvia Grinnell River (Fig. 3). Note that it is the only mode evident in the 1976/77 sample, the larger individuals in the population having been removed. Johnson (1980) maintains that the removal of the large population mode of Creswell Bay charr left only a small-sized, slow-growing group, with little capacity to yield a significant harvest. This appears to have happened to the Sylvia Grinnell River charr stock as well.

The modal age of charr in 1976/77 had fallen to 10 years from 13 years in 1948/50/51 (Fig. 4). By comparison to the marked reduction in modal length over this time period, the difference in model age seems relatively small. However, this would not be unexpected if this small mode was comprised of slow-growing individuals, many of which were relatively old for their size.

Mortality

The catch curve for 1948/50/51 has a gently sloping right-hand limb suggesting a relatively low mortality rate (Fig. 5). This is not surprising since commercial fishing was just beginning when the sample was taken. Examination of the curve from the 1958 data suggests mortality had increased only amongst the oldest charr. This could be attributable to the early commercial fishery. Age data for charr taken in 1958 were unavailable for those less than 11 years old, hence the left-hand limb of this curve is missing. The catch curve plotted from the 1976/77 data is markedly displaced to the left, indicating that the old charr have been removed from the stock.

A comparison of mortality rates of charr aged 13 to 18 years (14 to 18 years for 1958) is shown in Fig. 6. Instantaneous total mortality rates (Z) were calculated from the slopes of the straight lines fitted to the data. In each case the data show a good linear fit. These data indicate that instantaneous total mortality was relatively low in 1948/50/51 ($Z = 0.31$) and in 1958 ($Z = 0.14$). It had increased significantly ($Z = 0.70$) by 1976/77. If it is assumed that natural mortality has remained constant, the increase was due to increased fishing mortality (Table 1). Subsequently, annual survival (S) amongst these age groups dropped from 87% in 1958 to 50% in 1976/77 (Table 1). If natural mortality decreased, as it often does following exploitation (Tyler and Gallucci 1980), fishing mortality would be even higher than is calculated here.

Growth

Weight-length relationships for Arctic charr taken in 1976 and 1977 (sexes combined) are as follows:

1976 $\quad Log_{10} W = -5.2101 + 3.0724 \, Log_{10} L$
$\quad N = 255; \; SD_b = 0.0317$

1977 $\quad Log_{10} W = -5.3254 + 3.1368 \, Log_{10} L$
$\quad N = 848; \; SD_b = 0.0259$

Using analysis of covariance, no significant differences ($p>0.05$) were found between sexes or between years (sexes combined) with re pect to slopes or adjusted means.

Weight-length relationships of several charr stocks are shown in Table 2. Charr taken in the Sylvia Grinnell River show an increase in weight with length which is similar to other stocks. This increase appears to be isometric.

Mean condition factor, K, was lower in 1976 (K = 0.94, N = 255) than in 1977 (K = 1.06, N = 847) suggesting that 1976 was a poor growing year. Condition was lower over the entire range of sizes of charr sampled in 1976 compared with 1977 (Table 3). Johnson (1980) has observed that year to year variation in weight increase during the summer is quite high. The availability of food and time spent at sea no doubt contribute to this variation.

Charr from the Sylvia Grinnell River grow more slowly than those from the Robertson River on North Baffin Island, the Jayco River on Victoria Island, and the Tree River, on the mainland in the central Arctic (Fig. 7). All these charr stocks are subject to exploitation, with sport fisheries at the Robertson (Moshenko 1981) and Tree (Falk and Dahlke 1979) rivers and a commercial fishery at the Jayco River (Dahlke and Falk 1979). Tree River charr are well known for their rapid growth (Moshenko et al. 1983), as is the Sylvia Grinnell River stock for its slow growth (Grainger 1953). Also, there appears to have been an apparent decrease in growth rate of the Sylvia Grinnell stock by 1976/77 compared with the growth rate calculated by Grainger (1953) for 1948/50/51 (Fig. 7). Grainger's (1953) method of aging was used in the present study so this decrease is probably not due to a difference in aging technique.

As discussed earlier, Johnson (1980) found differences in growth rates between the large and small modes of charr investigated at Creswell Bay in 1962. Charr in the small mode ranged in age from 6 to 25 years while those in the large mode ranged from 11 to 28 years of age. Grainger (1953) expressed the growth rate of Sylvia Grinnell River charr as mean length at age. Differences in growth rates tend to be obscured when this technique is used (Johnson 1980). If the range in length at age from Grainger's (1953) sample is examined (Table 4) it can be seen that it is comprised of small, relatively old charr and large, relatively young charr. Charr aged 10 years ranged in length from 26.5 cm to 52 cm while those aged 17 years ranged from 36.5 cm to 70 cm in length. Therefore, the two size modes evident in Fig. 3 may well have been made up of charr with different growth rates. The growth rate presented by Grainger (1953) would be an average of the different growth rates, since mean length at age was used. Removal of the large, fast-growing mode by fishing would leave only the small, slow-growing mode resulting in the apparent decrease in growth rate observed by the present study (Fig. 7).

Johnson (1980) has observed bimodal size distributions in a number of Canadian Arctic charr stocks. However, the factors maintaining the segregation of the size groups are not known. Johnson (1976) has suggested that recruitment is controlled by density dependent factors in landlocked lakes. Amongst the anadromous stocks at Creswell Bay and Nauyuk Lake the density of the large stock does not appear to maintain the segregation between the two size groups. Johnson (1980) questions whether all members of the smaller mode, irrespective of age, are able to grow into the larger mode under appropriate conditions, or whether it becomes impossible after a certain age. Perhaps the size modes represent two separate forms of charr as advocated by a number of researchers (Johnson 1980).

The reduction in the density of the large modes at Creswell Bay, Nauyuk Lake and Sylvia Grinnell River appears to be related to exploitation. Continued, intense fishing pressure could be sufficient to prevent the return of the large size mode in these cases. Whether or not individuals in the small mode are capable of replenishing the larger size mode through accelerated growth will only be determined if fishing pressure is reduced.

Maturity and spawning potential

Grainger (1953) concluded that female charr from the Sylvia Grinnell River first reached sexual maturity at a length of about 450 mm and an age of about 12 years. Once they reach maturity charr in most areas of the Northwest Territories do not spawn every year (Johnson 1980) and most remain in freshwater the summer prior to spawning (Sprules 1952; Grainger 1953; Johnson 1980). However, a few spawners do return from the sea (Moore 1975) as was observed during the present. Eight percent of females and one percent of males captured were in spawning condition. No males under 500 mm in fork length and no females under 350 mm in fork length were mature (Table 5). No males under 11 years of age and no females under 10 years of age were mature (Table 6). The length and age distributions of charr in the Sylvia Grinnell River in 1976/77 suggest then that there were few fish large enough and old enough to be considered potential spawners (Fig. 3 and 4). Although the relationship between recruitment and spawning stock size amongst anadromous Arctic charr is not well understood (Johnson 1980) it could be that a paucity of spawners in the Sylvia Grinnell River stock results in poor recruitment and thus inhibits productivity. Apparently the charr stock was in a reduced state in 1966 since the commercial fishery terminated at that time owing to declining catch per unit of effort. Hence the reduced status of the stock in 1976/77 could have been related to

poor recruitment from a reduced spawning stock.

Stocks under stress from a fishery are less able to survive environmental changes and even temporary changes could reduce or prevent their full recovery (Ricker 1977). The Sylvia Grinnell River charr stock, in its present reduced state, may now also be particularly vulnerable to environmental degration.

SPORT FISHERY

An active sport fishery takes place at the Sylvia Grinnell River during summer. Four hundred and twenty-seven anglers interviewed spent a total of 871 h fishing in 1976 and 374 interviewed fished for 1 102 h in 1977 (Table 7). Obviously angling is an important recreational pastime in Frobisher Bay since 83% of those interviewed in 1977 were residents of the community. Mean length (36.4 cm, N = 137) and mean age (11.6 years, N = 123) of charr angled in 1976 was slightly larger and older respectively than in 1977 (33.8 cm, N = 259; 10.5 years, N = 218) (Fig. 8). It appears that the mean length (37.1 cm, N = 244) and age (11.3 years, N = 224) of charr available to anglers in 1977, as sampled by experimental gillnets (Fig. 9), was larger and older respectively than what the anglers took (Fig. 8). However, the converse was observed in 1976, where the mean fork length of charr taken by the experimental gillnets (28.8 cm, N = 118) (Fig. 9) was smaller and the mean age (9.2 years, N = 104) was younger than that taken by angling during that year (Fig. 8). However, the results of the experimental gillnetting in 1976 may not be representative, since it was carried out on only two consecutive days in late August. Angling took place throughout the duration of the study in 1976 and 1977 and experimental gillnetting in 1977 took place on four days over an 18 day period (Fig. 10). This figure indicates a gradual increase in the size of the charr in the river over the course of the summer, perhaps reflecting the return of migrants from the sea.

Most of the anglers interviewed were not successful at the Sylvia Grinnell River, but a small number of skillful anglers caught charr regularly. Their success appeared to be relatively constant throughout the 1976 season (Fig. 11). Angling success in 1977 showed a peak at the end of July (Fig. 12) coincident with the occurrence of the spring tide. Grainger (1953) observed that charr moved upstream to the falls on the incoming tides and then withdrew into the bay on the falling tide. This pattern is apparently repeated throughout the summer until the upstream overwintering migration takes place. Angling success is probably influenced by these movements.

In comparison to the quality of angling available at two well-known Arctic charr sport fisheries, namely the Tree and Robertson rivers, angling at the Sylvia Grinnell River is poor (Table 7). In 1978, 84% of anglers censused at the Tree River were successful in capturing at least one charr (Falk and Dahlke 1979) as were 95% at the Robertson River (Moshenko 1981) compared with 26% and 47% in 1976 and 1977, respectively, at the Sylvia Grinnell River. Mean fork length of charr taken at the Tree River was 75.6 cm and at the Robertson River 65.9 cm compared with 36.4 cm (1976) and 33.8 cm (1977) at the Sylvia Grinnell River (Table 7, Fig. 13). A high percentage of the catch from the Sylvia Grinnell River (93% in 1976, 84% in 1977) was retained compared with that at the Tree (24%) and Robertson (37%) rivers. Apparently anglers feel that if they are lucky enough to catch a charr at the Sylvia Grinnell River it is kept, whereas at the other locations mentioned, charr are plentiful and success is high, so most are released.

Compared with previous years, the size of charr angled at the Sylvia Grinnell River has declined drastically. Hunter (1958) reported 634 charr taken by anglers in 1958 (Table 7). Although he had no data on size of the angled catch he assumed it was similar to the mean size (2.21 kg) taken by the experimental gillnet fishery which took place in 1958. In 1976 census takers recorded a minimum of 212 charr kept from 229 landed during the period July 10 to August 19 (Table 7). The mean round weight per charr was 0.49 kg (N=137). In 1977, 379 of 415 charr landed during the period July 23 to August 15 were kept. The mean round weight per charr was 0.44 kg (N=259)(Table 7). According to Reiger (1982): "At one time eight-pound charr were abundant in the Sylvia Grinnell: last summer [1981] fish of any size were scarce."

SUBSISTENCE FISHERY

No data were collected from the subsistence [domestic] gillnet fishery in 1976. Subsistence gillnetting occurred below the falls during the latter half of August, 1977, and samples of the catch were secured on August 23 and 25 (Fig. 14). The mean length of these charr was 38.9 cm (N = 53) and mean weight was 0.73 kg (N = 53).

Difficulties were experienced in determining daily catches. Fishermen were approached but some were reluctant to allow their catch to be counted. Counts were then made at a distance while the catch was being removed from the nets. Most nets were about 32 m long with 89 mm mesh size (stretched measure). A daily record of the number of gillnets set in the river was kept beginning August 17 when this activity started. Catches were heavy initially, when the upstream migration of charr began but tapered off near the end of the month (Table 8). About 2 282 charr were captured by the subsistence gillnet fishery.

Snagging began on August 23, 1976 and on August 16, 1977. Since snagging does not lure the fish to the hook but depends upon impaling it by chance, it is successful only when applied to concentrations of fish. Snagging success increased dramatically at the time of the spring tide (Fig. 11,12), indicating that the charr had concentrated in the river on their upstream migration. As discussed previously, the spring tide is necessary to enable the charr to surmount the falls on their way upstream. Hence the upstream migration of charr in the Sylvia Grinnell River is predictable.

At least 1 920 charr were snagged in 1976 and 4 923 in 1977. Mean fork length of snagged charr taken in 1976 was 22.5 cm (N = 644) and 32.8 cm (N = 292) in 1977. Mean round weight calculated from the weight-length relationship was 0.37 kg.

Charr taken by snagging were much smaller in 1976 than in 1977 (Fig. 15) although the reason for this is not clear. Generally it appears that small charr could be selectively taken by snagging since they are virtually powerless to escape once impaled on the hook. On the other hand, large charr could tear loose if superficially hooked. Some large charr taken by gillnets bore marks resembling those made by snag hooks. On August 21 and August 26, 1977, the snagging technique was carefully observed and 41% and 32%, respectively, of charr hooked escaped before they could be landed.

The most disturbing feature of the snagging fishery is the waste of charr. This was readily apparent to the observers. Many of the charr taken were considered too small to keep and were simply discarded on the rocks. A comparison of the size of charr taken by the different fisheries is shown in Fig. 14.

SYLVIA GRINNELL LAKE

Most charr taken in Sylvia Grinnell Lake on August 8 and 9, 1977 were under 50 cm in length (Fig. 16). At this time the anadromous component of the stock would still be at sea. Hence this sample is probably composed of non-anadromous charr and perhaps some anadromous spawners.

EFFECT OF FISHERIES ON THE CHARR STOCK

Hunter (1976) outlined the history of exploitation of this charr stock up to 1967. Fishing was limited to a traditional Inuit harvest until 1947, when commercial fishing began. Grainger's (1953) data indicate that the charr stock was relatively strong at the outset of commercial fishing. Grainger (1948) reported that a total of 7 700 charr were netted in 1948. Wright (1950) stated 2 167 charr were taken by the commercial fishery in 1950. Mean round weight per charr was 2.95 kg hence approximately 22 700 kg were taken in 1948 and 6 400 kg in 1950.

The commercial fishery did not operate from 1951 to 1957 but charr were taken by the subsistence and recreational fisheries (Hunter 1976). Hunter (1958) estimated the combined annual harvest from these two fisheries to be 12 000 kg in 1958. Commercial fishing was reestablished in 1958, this time by the Department of Northern Affairs, and an experimental gillnet fishery was conducted to determine the status of the stock (Hunter 1958). As shown in Fig. 3, the stock had not changed significantly since 1948. Apparently the first commercial fishery did not deplete the stock nor did the subsistence and recreational fisheries that followed immediately afterward.

On the strength of the 1958 evaluation an annual quota of 4 500 kg was allowed for the commercial fishery (Hunter 1976). It was estimated that the stock could sustain a combined commercial, recreational and subsistence harvest of 20 400 kg annually (Hunter 1958). Commercial production is shown in Table 9. Initially the quota was taken easily within a few days of the onset of fishing each year. However, catch per unit of effort declined steadily until commercial fishing was no longer worthwhile and the fishery ceased after 1966 (Hunter 1976). If the subsistence and recreational fisheries are assumed to have taken 12 000 kg per year during the operation of the commercial fishery, a total annual harvest of nearly 18 000 kg was likely at the outset. Apparently the charr stock could not sustain this yield and the fishery collapsed.

The subsistence and recreational fisheries that persisted after the cessation of commercial fishing still harvested large numbers of charr (Table 10) although the total landed weight was far less than previously taken, owing to the drastic reduction in the mean size of the charr. This continued fishing is probably responsible for the failure of the charr stock to recover to this day. Personnel from the Department of Fisheries and Oceans (DFO) observed this fishery during the summer of 1982 and results indicate that the stock had not yet recovered (W. Kowalczyk pers. comm.). A limited amount of gillnetting by DFO staff between August 19 and 31 (38, 63, 89 and 114 mm mesh size) captured charr with a mean length of 31.9 cm (N=32) and a mean age of 9 yr (N=27)(Fig. 17). Mean weight was 0.45 kg (N=31). These data were not used in the earlier comparison owing to the small sample size; however, they do support the observation that the stock is still in a reduced state.

Compared to other fishing activities, angling was responsible for harvesting the least number of charr although this activity was pursued over the longest period of time (Table 11). Four hundred and fifteen charr weighing a total of 181 kg were taken, with a mean round weight per charr of 0.44 kg. Subsistence gillnetting began with the first signs of the run near the spring tide in August and at least 2 282 charr weighing a total of 1 666 kg were taken. The mean weight per charr was 0.73 kg. Snagging was responsible for the harvest of the most charr. At least 4 923 were taken weighing a total of 1 822 kg. These charr were also the smallest with a mean weight per charr of only 0.37 kg. As a result many were discarded.

RECOVERY OF THE CHARR STOCK

Charr grow very slowly, thus prerecruits to the fishable stock are composed of many year classes (Hunter 1976). Heavy exploitation of the fishable stock does not affect recruitment immediately. Recovery of the fishable stock can be quite rapid if fishing is ceased and the prerecruits are allowed to grow to fishable size. Such a rapid recovery took place with the commercial charr fishery at the Ekalluk River, Victoria Island (Kristofferson and Carder 1980).

There, fishing ceased in 1969 when the size of the charr had declined to a point where they were of little commercial value (Barlishen and Webber 1973). After a closure of three years, during which time the charr grew to an acceptable size, the fishery resumed in 1973 and remains viable today. However, the situation at the Sylvia Grinnell River could differ. Since the commercial fishery at the Ekalluk River is restricted to gillnets with a minimum mesh size of 139 mm, only the large charr are vulnerable to the gear. That is, the prerecruits were protected from the fishery and remained abundant. At the Sylvia Grinnell River even small charr are vulnerable to the gear, especially to snagging, and thus are recruited to the fishery at a very small size (Fig. 3) and early age (Fig. 4), well before the onset of sexual maturity. As a result, numbers of prerecruits are reduced, as is spawning potential. In effect, the recovery capacity of the charr stock in the Sylvia Grinnell River may be depressed. All that appears to remain of the robust stock Grainger (1953) observed in 1948/50/51 is the small, slow-growing mode of charr that was discussed in detail earlier. Whether these charr represent a distinct stock with a fixed, slow growth rate or whether individuals in this mode still have the capacity to rejuvenate the large mode through accellerated growth, if given the chance, is not known. In order to determine this, fishing pressure must be reduced.

The most effective way to determine if recovery is possible would be to cease all fishing activity at the river. Signs of recovery, if it does occur, should be evident within three to five years. However, such a closure would bring unnecessary hardships upon the community of Frobisher Bay. Angling is an important recreational pastime here and does not harvest large numbers of charr (Table 11), therefore allowing it to continue probably would not interfere significantly with the recovery of the stock. Subsistence fishing is, no doubt, very important to a small number of fishermen in Frobisher Bay, yet it is this fishery that is largely responsible for the prevention of the recovery of the stock. Ideally, if an alternate source of charr could be secured to fulfill this subsistence need, gillnetting could cease and recovery would be enhanced. An ample supply of charr is produced by the Pangnirtung commercial fishery 300 km away. Unless the destructive and wasteful practise of snagging is discontinued, hopes for recovery of this stock are bleak. Charr are extremely vulnerable when they congregate at the base of the falls on their upstream migration. Closure of this area of the river to all types of fishing is necessary to protect the stock. This is the only area where snagging is effective, and therefore, closure here will eliminate this practise. If incorporated, this strategy could contribute to the recovery of the stock. It is difficult to determine the time required to effect a recovery since it is not really known how the small size mode will respond to reduced fishing pressure. Any recovery will probably depend to a large extent on the continued intensity of fishing. If only angling is allowed, a measure of recovery could be effected in three to five years. Annual experimental gillnetting would provide a means to monitor the progress of the recovery. Once recovery is achieved assignment of a quota would be necessary to maintain the long-term viability of the fishery.

The future of this charr fishery depends upon whether or not this recommended program receives the support of the people of Frobisher Bay. A public meeting was held in Frobisher Bay on November 28, 1978, where DFO personnel explained the results of this study in detail to those present. Various alternatives were discussed, including total and partial closure of the river to fishing. In subsequent discussions it was decided that a questionnaire would be circulated by mail to the citizens of Frobisher Bay asking for their concerns and suggestions regarding the future management of the Sylvia Grinnell River. Response to the questionnaire was very poor. Another public meeting was held in Frobisher Bay on January 22, 1981. Once again DFO explained the results of this study and the alternatives for recovery were outlined. The Frobisher Bay Hunters and Trappers Association (HTA) was concerned with the small size of the charr in the river but did not express a willingness to support a closure of any kind. However, at an HTA meeting in Frobisher Bay held on June 10, 1982, and attended by DFO personnel, some of the people appeared to be amenable to a closure of the river to all methods of fishing from the falls to a point 100 m downstream. Recovery of the Sylvia Grinnell River charr stock to its former productive state will take place only with the cooperation of all parties involved in the fishery.

RECOMMENDATIONS

1. It is recommended that the Sylvia Grinnell River be closed to all types of fishing from the head of the falls to a point not less than 100 m downstream.
2. It is recommended that an alternate source of Arctic charr be secured to satisfy the subsistence needs of the Inuit of Frobisher Bay, so that subsistence gillnet fishing can cease until the stock recovers. This will shorten the recovery period.
3. It is recommended that the minimum mesh size for subsistence gillnets be restricted to 139 mm, stretched measure, if recommendation #2 is not implemented. The annual catch from the subsistence gillnet fishery is to be monitored in this event.
4. It is recommended that an experimental gillnet program be carried out annually on the upstream migration of charr, in order to determine the recovery rate of the stock.

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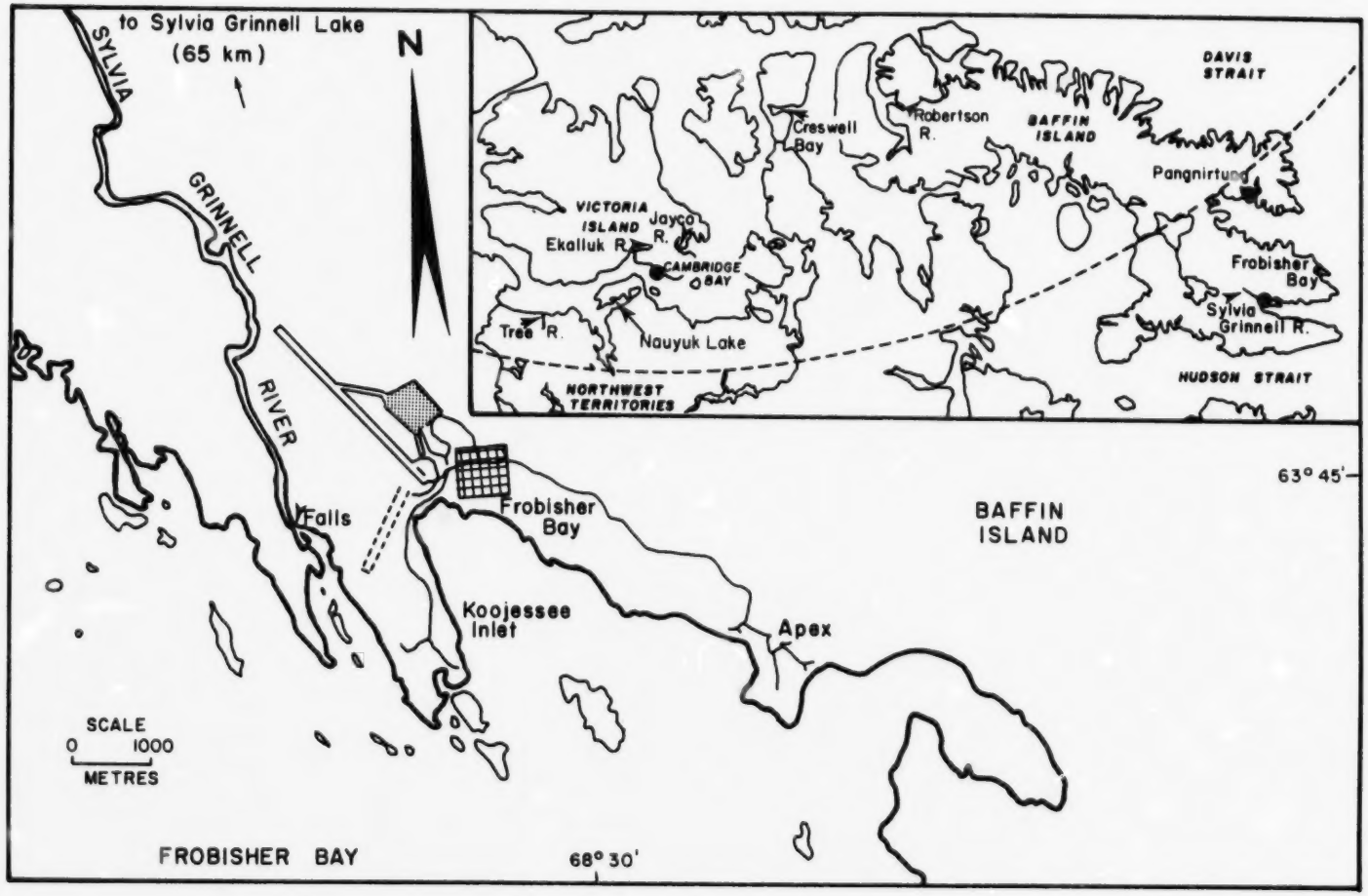

Fig. 1. Map of the Frobisher Bay area, Baffin Island, showing the Sylvia Grinnell River.

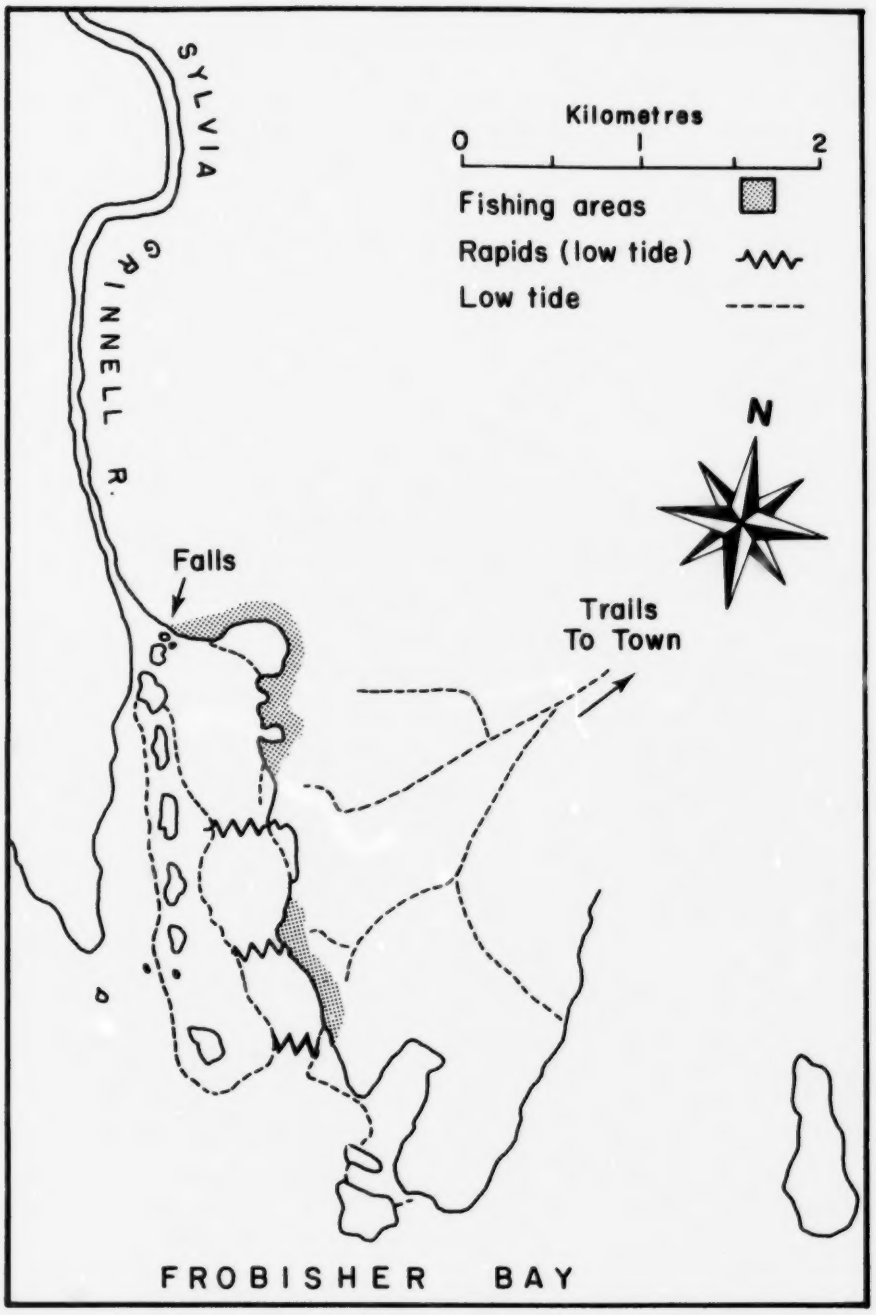

Fig. 2. Map of the outlet of the Sylvia Grinnell River showing the study area.

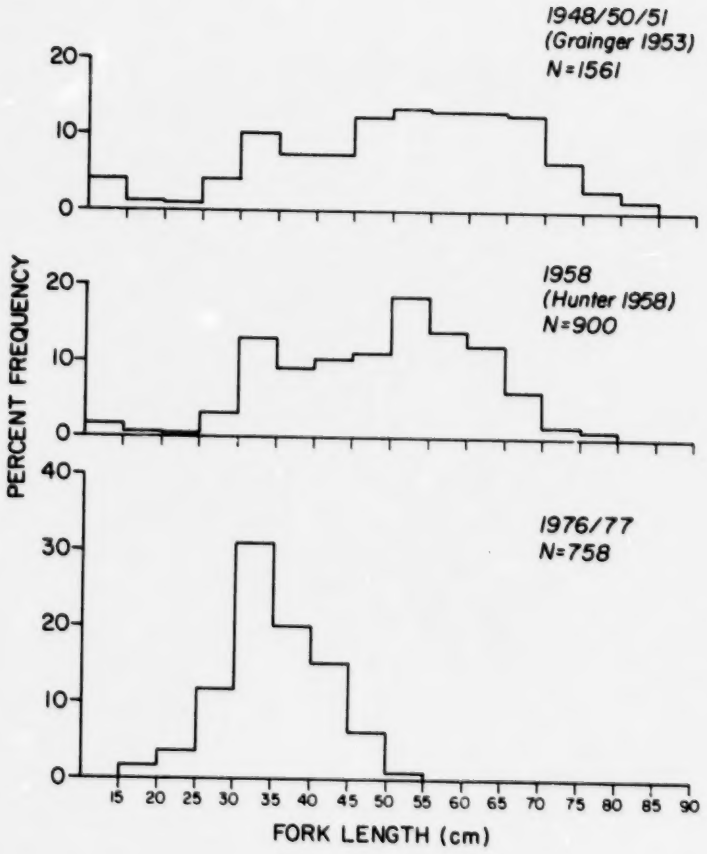

Fig. 3. A comparison of length-frequency distributions of samples of Arctic charr taken from the Sylvia Grinnell River during 1948/50/51, 1958 and 1976/77.

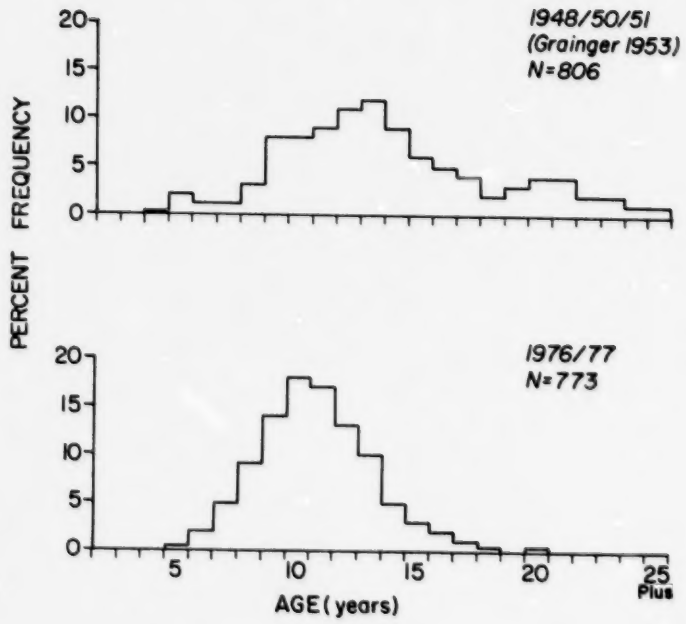

Fig. 4. A comparison of age-frequency distributions of samples of Arctic charr taken from the Sylvia Grinnell River during 1948/50/51 and 1976/77.

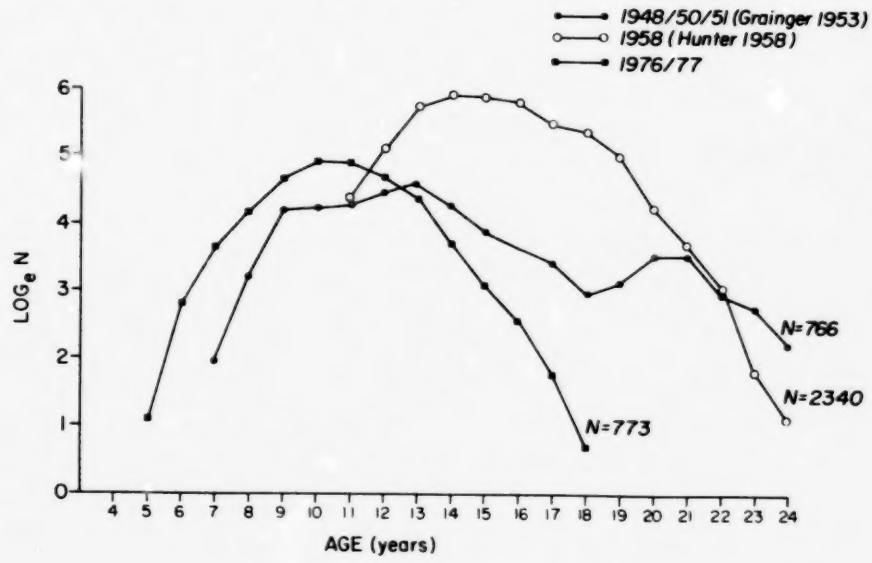

Fig. 5. Catch curves for Arctic charr taken from the Sylvia Grinnell River during 1948/50/51, 1958 and 1976/77.

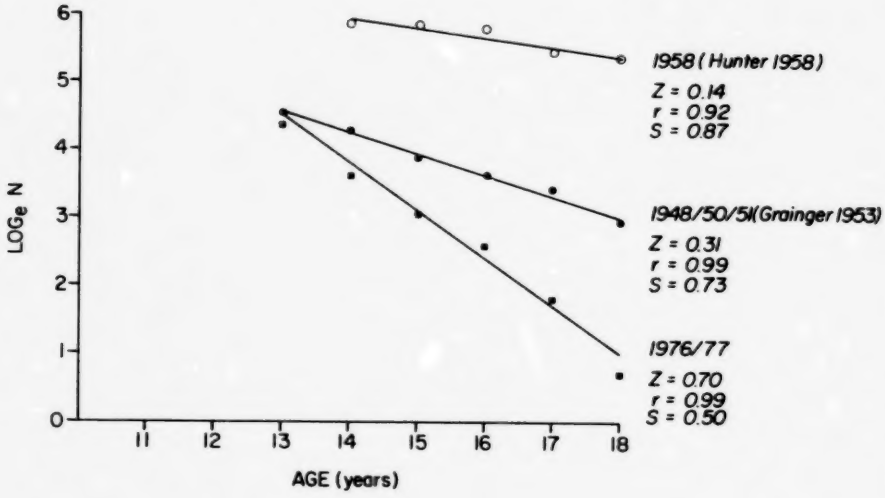

Fig. 6. A comparison of mortality rates (catch curve) for Arctic charr, aged 13(14) to 18 years, taken from the Sylvia Grinnell River during 1948/50/51, 1958 and 1976/77.

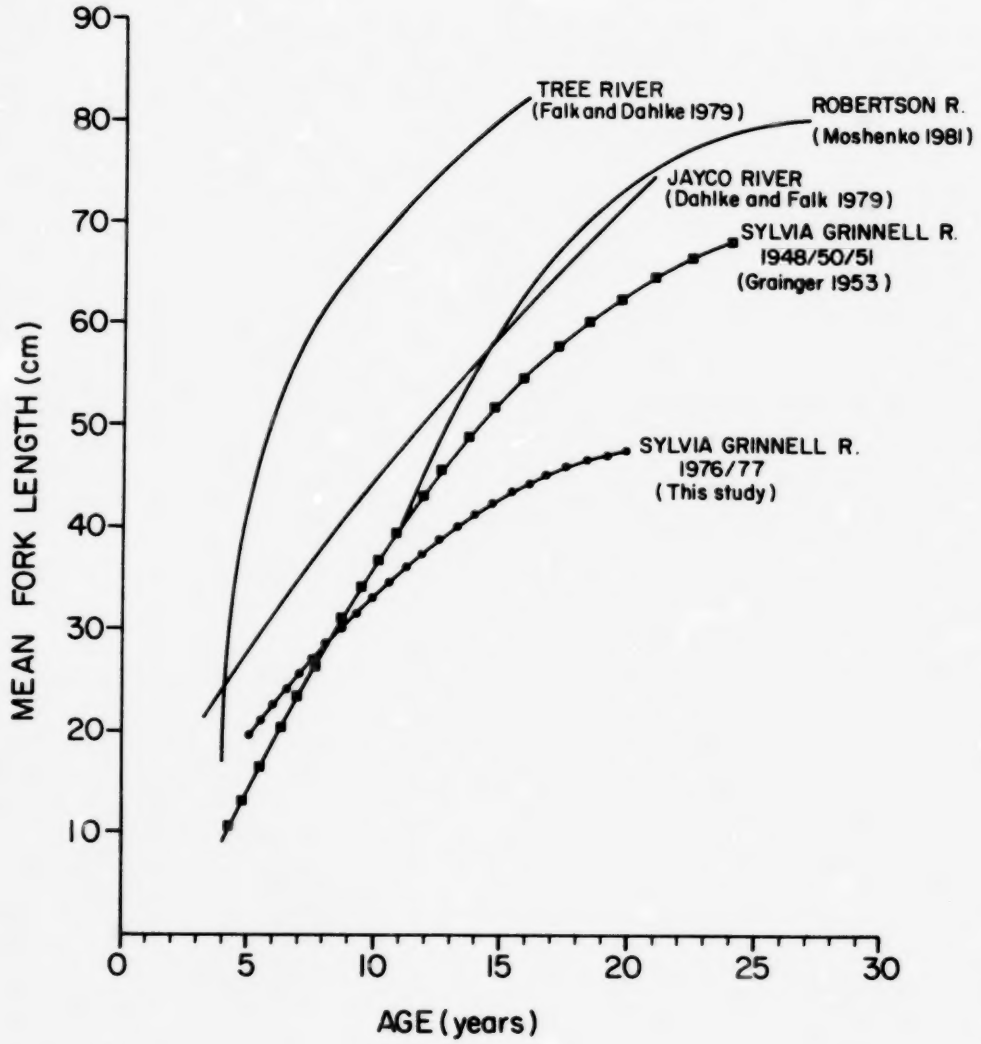

Fig. 7. A comparison of growth rates of Arctic charr taken from the Sylvia Grinnell River in 1948/50/51 and 1976/77 with those of Arctic charr from other rivers in the Northwest Territories.

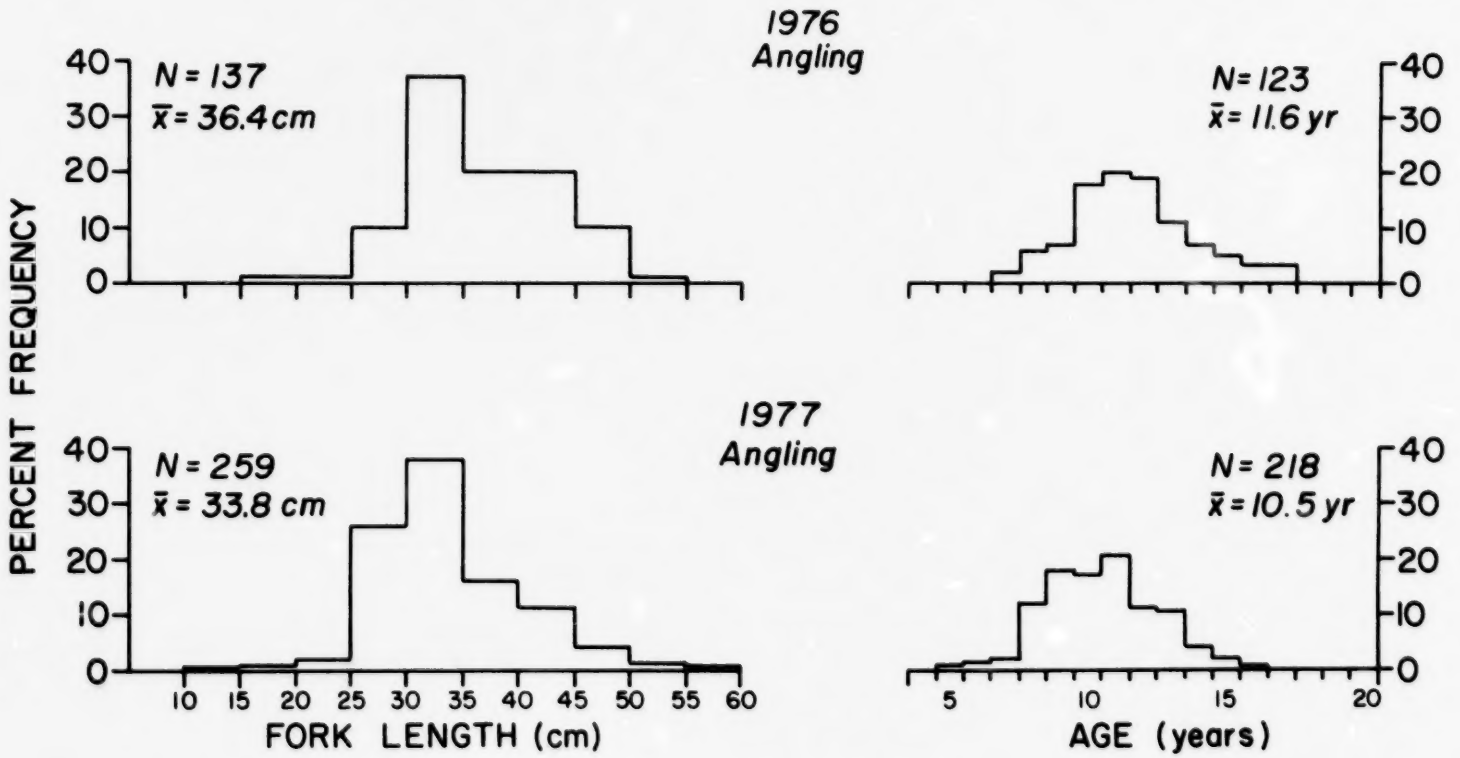

Fig. 8. A comparison of length- and age-frequency distributions of Arctic charr taken from the Sylvia Grinnell River by angling in 1976 and 1977.

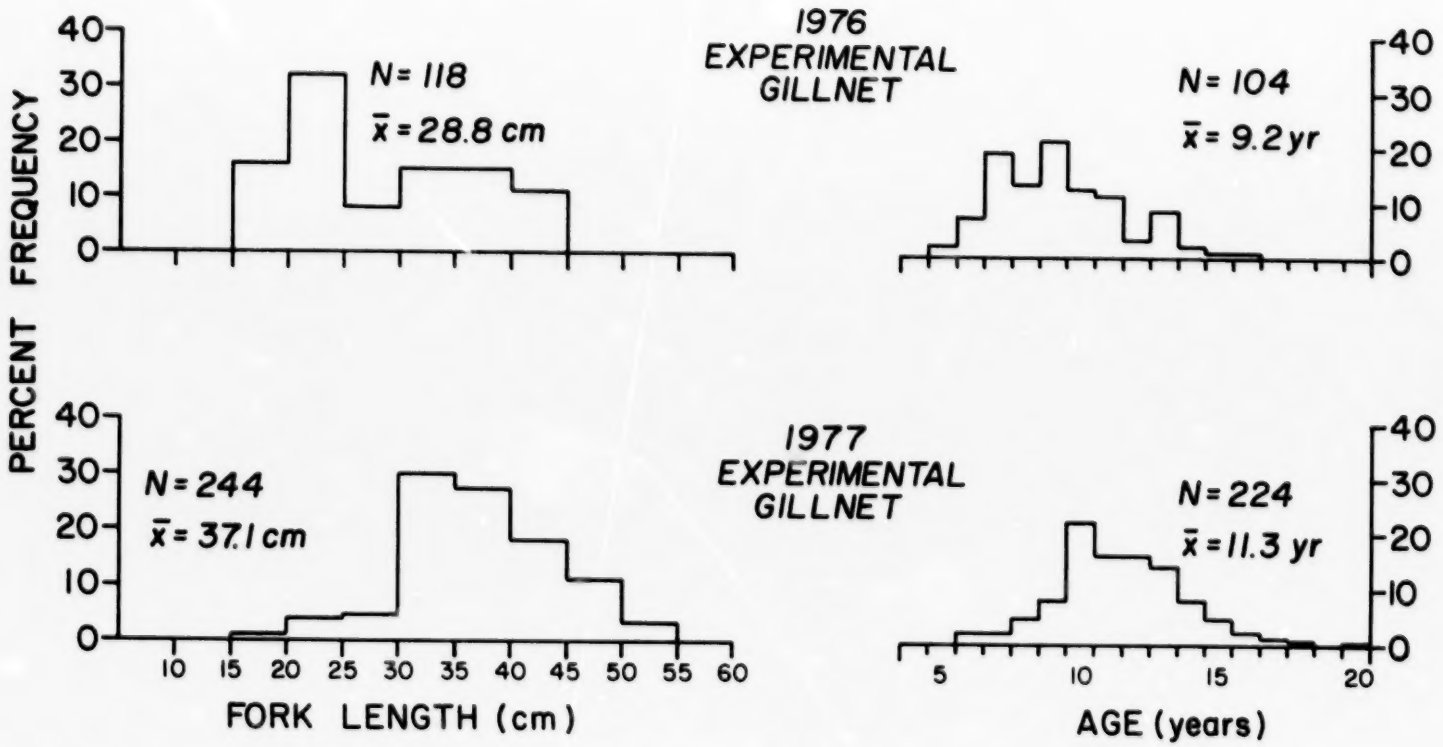

Fig. 9. A comparison of length- and age-frequency distributions of Arctic charr taken from the Sylvia Grinnell River by experimental gillnet in 1976 and 1977.

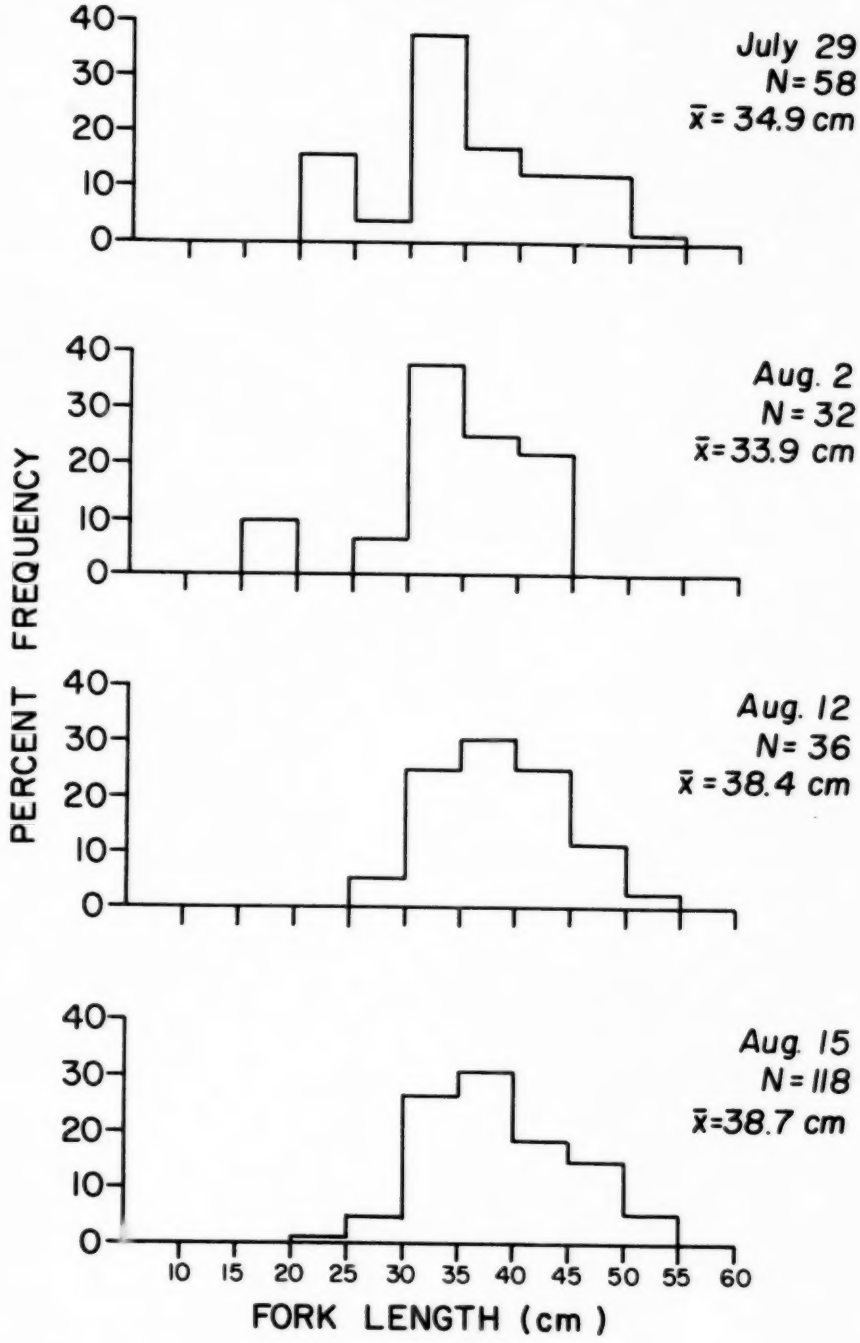

Fig. 10. Length-frequency distributions of Arctic charr taken from the Sylvia Grinnell River by experimental gillnets on four occasions during 1977.

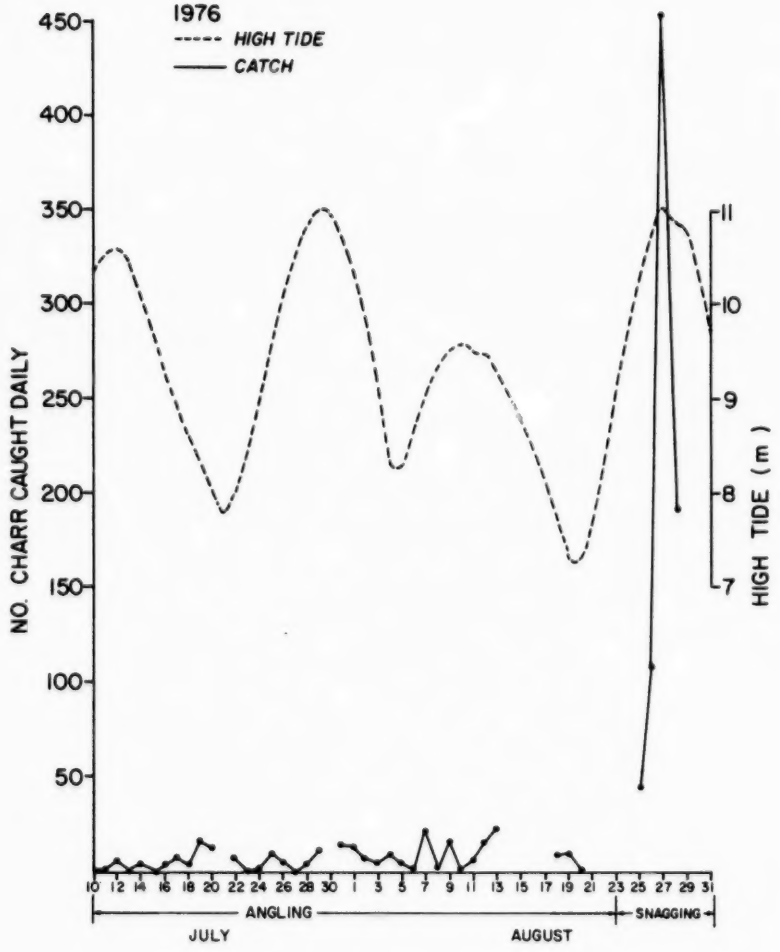

Fig. 11. Daily catch of Arctic charr from the Sylvia Grinnell River taken by angling and snagging compared with daily high tide level, 1976.

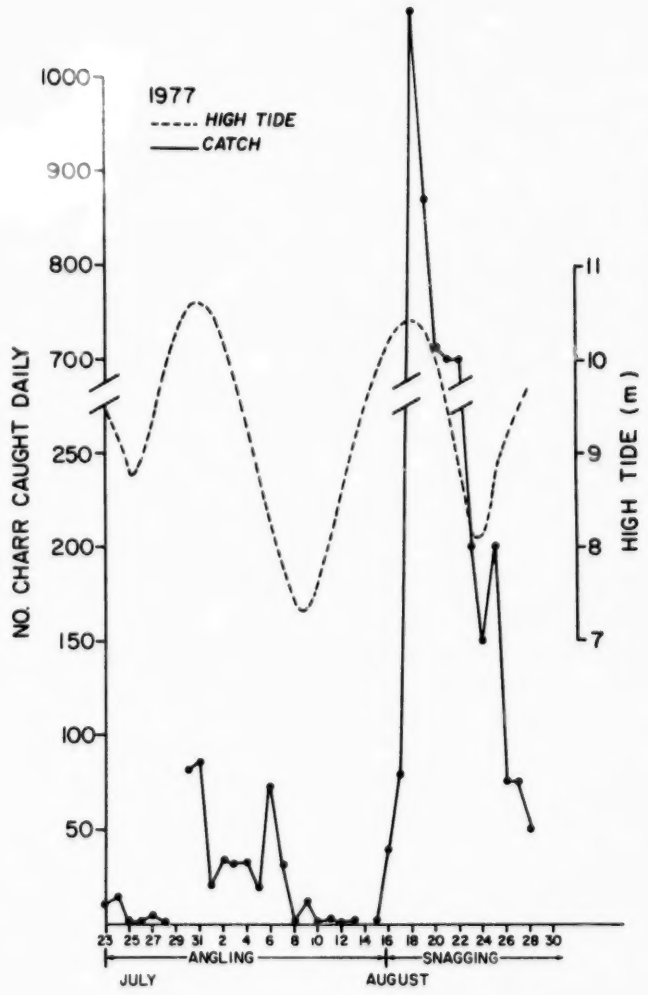

Fig. 12. Daily catch of Arctic charr from the Sylvia Grinnell River taken by angling and snagging compared with daily high tide level, 1977.

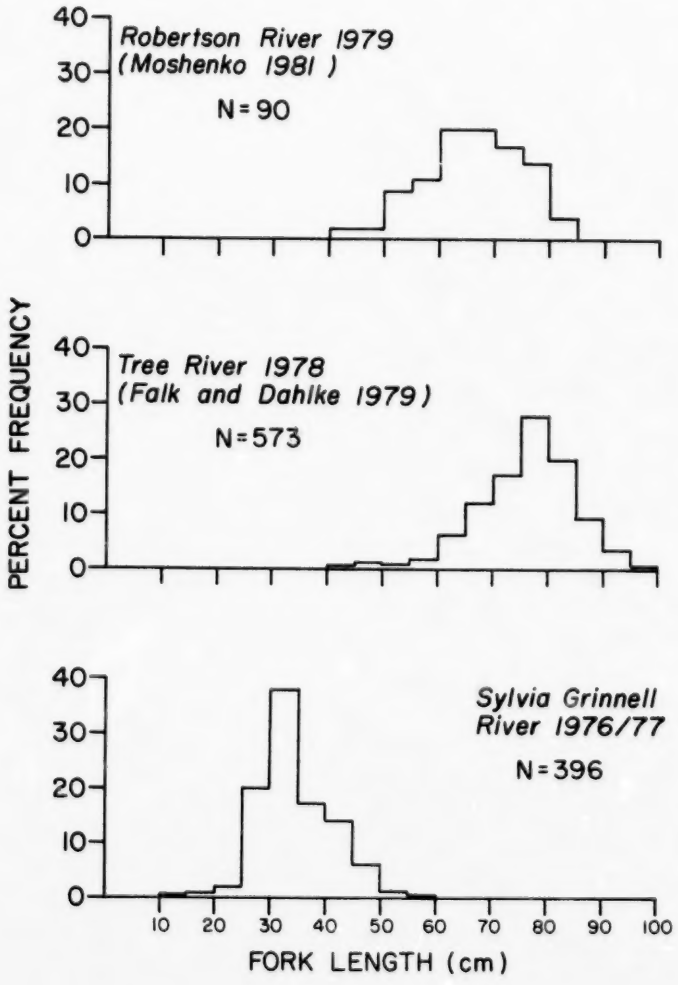

Fig. 13. A comparison of length-frequency distributions of Arctic charr taken by angling from the Sylvia Grinnell River in 1976/77, the Tree River in 1978 and the Robertson River in 1979.

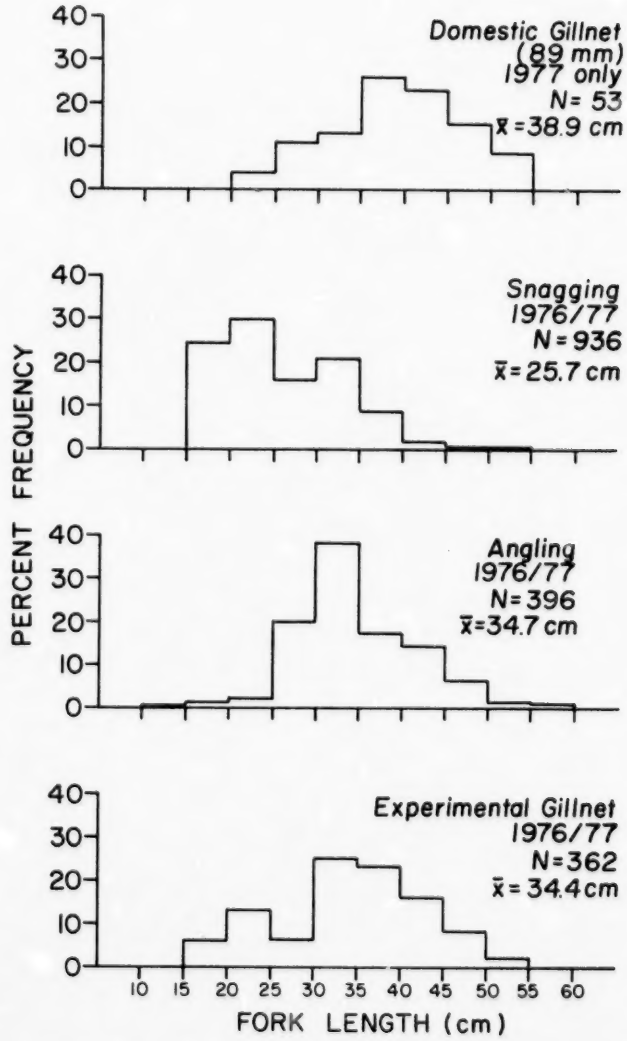

Fig. 14. A comparison of length-frequency distributions of Arctic charr taken by different types of gear from the Sylvia Grinnell River, 1976/77.

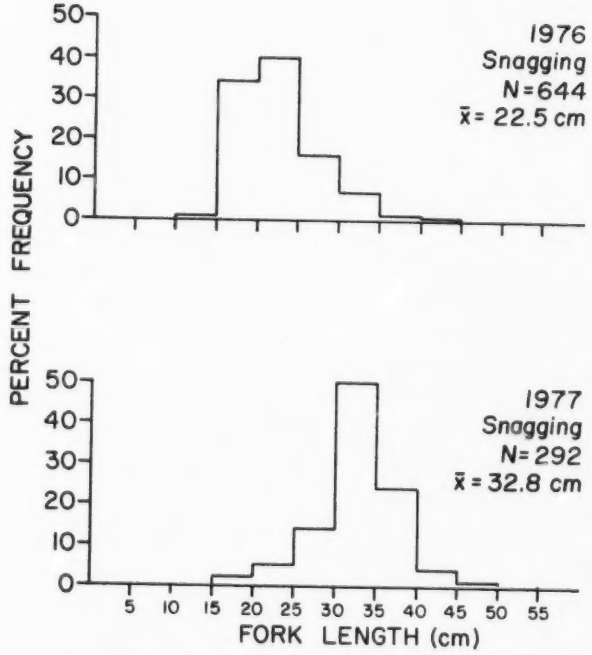

Fig. 15. A comparison of length-frequency distributions of Arctic charr taken from the Sylvia Grinnell River by snagging in 1976 and 1977.

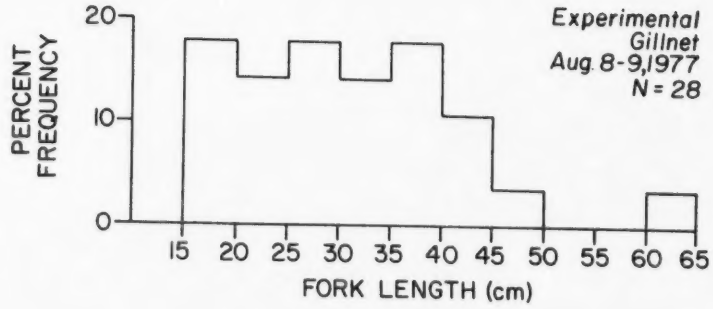

Fig. 16. Length-frequency distribution of Arctic charr taken from Sylvia Grinnell Lake by experimental gillnet in 1977.

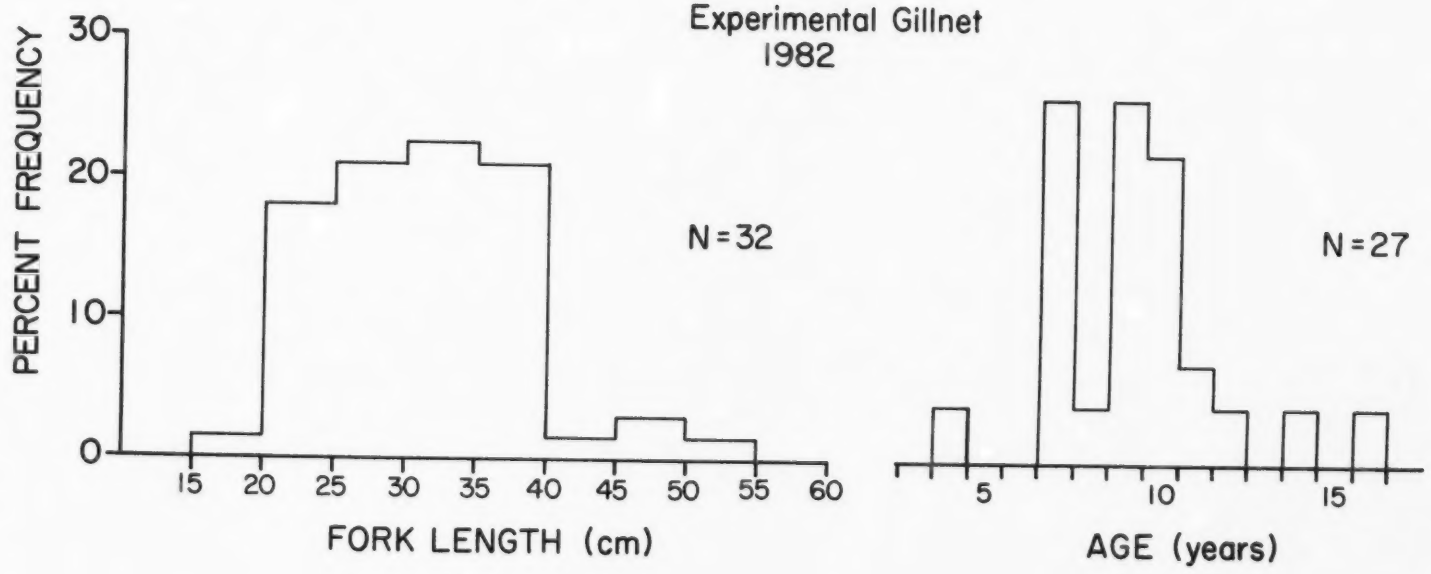

Fig. 17. Length- and age-frequency distributions of Arctic charr taken from the Sylvia Grinnell River by experimental gillnet in 1982.

Table 1. Instantaneous total and fishing mortality and annual survival of Arctic charr, aged 13-18 years, from the Sylvia Grinnell River in 1948/50/51, 1958 and 1976/77.

Year(s)	Age Groups (years)	Instantaneous Total Mortality (Catch Curve) Z	Instantaneous Fishing Mortality (Z-0.13) F	Annual Survival S(%)
1948/50/51	13-18	0.31	0.18	73
1958	14-18	0.14	0.01[a]	87
1976/77	13-18	0.70	0.57	50

[a]Sport and subsistence fishing is known to have taken place prior to and during 1958 so fishing mortality did occur. However, it was probably light. The estimation of instantaneous natural mortality (0.13) for these age groups may be too high.

Table 2. Weight-length relationships of Arctic charr from a number of locations compared with those from the Sylvia Grinnell River, 1976 and 1977. Log W = log a + n log L, where W=weight in grams, L=fork length in millimetres. Data tabulated by Johnson (1980).

Location	Date	n	log a
Sylvia Grinnell R.	10/7 to 28/8/76	3.0724	-5.2101
Sylvia Grinnell R.	23/7 to 28/8/77	3.1368	-5.3254
Robertson R.[a]	26/8/73	3.0041	-4.9933
Creswell Bay[b]	30/7 to 13/8/75	3.2653	-5.6875
Nauyuk Lake[c]	15/6 to 15/7/75	3.1668	-5.5062
Nauyuk Lake[c]	1/8 to 10/9/75	3.1077	-5.2281

[a]Peet (unpublished).

[b]Sekerak et al. (1976).

[c]Johnson (unpublished).

Table 3. Condition factor (K) of Arctic charr caught in the Sylvia Grinnell River in 1976 and 1977.

Length Interval	1976		1977	
mm	N	K	N	K
150 - 199	20	0.89	9	1.03
200 - 249	39	0.95	34	1.03
250 - 299	24	0.96	124	1.01
300 - 349	69	0.91	325	1.02
350 - 399	45	0.97	190	1.10
400 - 449	41	0.95	98	1.11
450 - 499	15	0.98	50	1.13
500 - 549	2	1.08	16	1.17
550 - 599	-	-	1	1.12
TOTAL	255		847	
MEAN		0.94		1.06

Table 4. Age, mean length and size range of Arctic charr from the Sylvia Grinnell River, 1948, 1950 and 1951. From Grainger (1953).

Age (yr)	Number	Mean Length (cm)	Length Range (cm)
4	3	9.0	8.5 - 10.0
5	18	13.0	11.0 - 14.5
6	7	13.9	12.5 - 16.5
7	7	17.2	14.5 - 28.5
8	25	30.2	17.0 - 39.5
9	68	33.7	18.5 - 46.5
10	68	36.3	26.5 - 52.0
11	73	41.4	29.5 - 55.0
12	85	42.5	30.5 - 57.0
13	96	48.4	30.5 - 65.0
14	71	51.0	36.0 - 63.0
15	48	55.3	31.0 - 67.5
16	38	55.7	44.0 - 68.5
17	31	55.9	36.5 - 70.0
18	19	60.0	46.0 - 70.5
19	23	61.3	46.5 - 74.0
20	35	64.9	55.0 - 76.5
21	35	64.2	50.0 - 76.5
22	19	65.8	44.0 - 78.5
23	16	67.8	51.0 - 81.5
24	9	67.8	58.5 - 78.5
24 plus	12	68.5	51.0 - 82.5

Table 5. Percent of Arctic charr, by length interval, captured in spawning condition while migrating up the Sylvia Grinnell River in 1976/77.

Length Interval (mm)	Males		Females	
	N	% Mature	N	% Mature
150 - 199	8	0	15	0
200 - 249	23	0	32	0
250 - 299	47	0	71	0
300 - 349	158	0	130	0
350 - 399	97	0	87	2
400 - 449	73	0	52	25
450 - 499	28	0	31	45
500 - 549	9	33	6	67
500 - 599	1	0	-	-
TOTAL	441	1	424	8

Table 6. Percent of Arctic charr, by age, captured in spawning condition while migrating up the Sylvia Grinnell River in 1976/77.

Age (yr)	Males		Females	
	N	% Mature	N	% Mature
5	3	0	-	-
6	5	0	11	0
7	14	0	24	0
8	32	0	32	0
9	56	0	52	0
10	68	0	72	4
11	72	1	60	7
12	63	0	8	13
13	41	0	39	8
14	17	0	21	19
15	11	9	11	18
16	7	0	6	33
17	4	0	2	0
18	2	50	-	-
19	-	-	-	-
20	-	-	2	100
TOTAL	395	>1	340	6

Table 7. A comparison of creel census data for Arctic charr angled in the Sylvia Grinnel River in 1958, 1976-77, the Tree River in 1978 and the Robertson River in 1979.

Location	No. Anglers Censused	Total Catch	% Anglers Successful	No. Fish Retained (%)	Total Hours Fished	Catch/ Angler Hour	No. Fish Sampled	Mean Round Weight (kg)	Mean Fork Length (cm)
Sylvia Grinnell 1977	374	415	47	379 (84)	1 102	0.4	259	0.44	33.8
Sylvia Grinnell 1976	427	229	26	212 (93)	871	0.3	137	0.49	36.4
Sylvia Grinnell 1958	87	634	-	-	2 330	0.3	902[c]	2.21	48.0
Tree River[a] 1978	472	2 186	84	524 (24)	4 495	0.5	573	4.90	75.6
Robertson River[b] 1979	77	368	95	135 (37)	307	1.2	19	3.00	65.9

[a] from Falk and Dahlke 1979.

[b] from Moshenko 1980.

[c] samples taken by experimental gillnet. See text for explanation.

Table 8. Catch record of the subsistence gillnet fishery in the Sylvia Grinnell River, August 1977.

Date	No. Nets (ca 32m in length)	Hours Set	Catch		Total Daily Catch
			Calculated	Counted	
Aug. 17	4	8	203[a]		203
18	5	8	253[a]		253
19	5	7	222[a]		222
20	7	8	355[a]		355
21	7	8	355[a]		355
23	1	10		150	150
23	2	7	200[b]	200	400
24	1	12		130	130
24	1	6		50	50
25	1	4		16	16
25	1	4	15[c]		15
25	1	3		10	10
25	1	24	89[c]		89
25	1	1	4[c]		4
25	1	2.5	9[c]		9
26	1	1		15	15
26	1	24		3	3
27	1	24	3[d]		3
28	5	No Observations Made			
TOTAL					2 282

[a]Calculated using catch per unit of effort of 89mm panel from experimental gillnet set of August 15.

[b]Assumed catch similar to that counted from adjacent net.

[c]Calculated using catch per unit of effort of other gillnets lifted August 25 where catch was counted.

[d]Assumed catch similar to that of August 26.

Table 9. Annual harvest statistics for Arctic charr from the Sylvia Grinnell River, 1958-66.

Year	Commercial[a] Harvest kg	Total Harvest (Includes estimated subsistence and recreational harvest of 12,000 kg)[b] kg
1958	5 834	17 834
1959	9 803	21 803
1960	5 532	17 532
1961	4 674	16 674
1962	4 688	16 688
1963	4 920	16 920
1964	3 824	15 824
1965	5 588	17 588
1966	4 658	16 658

[a]From Hunter (1958) and Hunter (1976). Quota was 4 500 kg.

[b]From Hunter (1958) for 1958. It is assumed that this level of harvest continued until 1966.

Table 10. Annual harvest, mean round weight per charr and number of charr taken by fisheries at the Sylvia Grinnell River in 1948, 1950, 1958 and 1977.

Year	Annual Harvest (kg)	Mean Round Weight per Charr (kg)	Number of Charr
1948[a]	22 700	2.95	7 700
1950[b]	6 400	2.95	2 167
1958[c]	17 834	2.20	8 106
1977	3 667	0.48	7 620

[a]From Grainger (1948).

[b]From Wright (1950).

[c]From Hunter (1958).

Table 11. Number of days fished, harvest, mean round weight per charr and number of charr taken by angling, subsistence gillnetting and snagging at the Sylvia Grinnell River, 1977.

Fishery	No. Days Fished	Harvest (kg)	Mean Round Weight per Charr (kg)	No. Charr
Angling	22	181	0.44	415
Subsistence Gillnets	11	1 666	0.73	2 282
Snagging	13	1 822	0.37	4 923
TOTAL		3 669		7 620

Appendix 1. Summary of biological data by length interval for Arctic charr taken by angling in the Sylvia Grinnell River, 1976.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
150	-	-	-	-	-	-	1	199	75	-	0.95	0	1	199	75	-	0.95	0
200	-	-	-	-	-	-	1	245	100	-	0.68	0	1	245	100	-	0.68	0
250	7	275	186	56	0.87	0	7	285	221	37	0.96	0	14	280	204	49	0.92	0
300	27	324	316	65	0.92	0	24	326	302	54	0.87	0	51	325	309	60	0.90	0
350	15	367	462	88	0.93	0	12	378	496	69	0.92	0	27	371	477	81	0.92	0
400	17	424	682	107	0.89	0	11	420	711	111	0.96	9	28	422	694	108	0.92	4
450	5	464	955	148	0.95	0	9	472	1017	185	0.96	11	14	470	995	170	0.96	7
500	1	536	1625	-	1.06	0	-	-	-	-	-	-	1	536	1625	-	1.06	0
TOTAL	72						65						137					
MEAN		364	483	265	0.91			364	491	286	0.91			364	487	274	0.91	

Appendix 2. Summary of biological data by age for Arctic charr taken by angling in the Sylvia Grinnell River, 1976.

AGE (YR)	MALES							FEMALES							COMBINED						
		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
7	1	324	-	250	-	0.74	0	1	199	-	75	-	0.95	0	2	262	88.4	163	124	0.84	0
8	6	310	24.9	283	68	0.94	0	1	265	-	200	-	1.07	0	7	304	28.4	271	70	0.96	0
9	3	307	4.0	250	50	0.86	0	6	289	29.9	229	87	0.91	0	9	295	25.5	236	74	0.89	0
10	10	334	60.4	380	237	0.90	0	12	346	45.2	419	211	0.94	0	22	340	51.7	401	219	0.92	0
11	12	357	61.6	452	264	0.92	0	13	338	28.0	337	116	0.84	0	25	347	47.1	392	205	0.88	0
12	15	364	44.0	465	207	0.92	0	8	361	46.4	447	197	0.90	0	23	363	43.8	459	199	0.91	0
13	8	399	47.3	619	206	0.94	0	5	403	64.1	635	327	0.90	20	13	401	51.8	625	246	0.92	8
14	5	403	48.3	610	204	0.91	0	3	435	54.5	833	325	0.98	0	8	415	49.6	694	260	0.93	0
15	4	446	77.7	919	515	0.95	0	2	421	22.6	650	141	0.86	0	6	438	62.3	829	427	0.92	0
16	2	413	10.6	600	71	0.85	0	2	475	12.7	1200	71	1.12	0	4	444	37.3	900	351	0.99	0
17	2	407	7.1	550	71	0.81	0	2	472	21.9	1075	35	1.03	0	4	439	39.5	813	307	0.92	0
TOTAL	68							55							123						
MEAN		365	60	483	267	0.91			358	65.8	475	300	0.92			362	62.3	480	281	0.91	
MEAN AGE	11.6																				

Appendix 3. Summary of biological data by length interval for Arctic charr taken by angling in the Sylvia Grinnel River, 1977.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
100	-	-	-	-	-	-	1	127	150	-	7.32	0	1	127	150	-	7.32	0
150	-	-	-	-	-	-	-	-	-	-	-	-	1	181	50	-	0.84	0
200	3	223	208	88	1.85	0	1	246	125	-	0.84	0	6	231	167	72	1.39	0
250	24	285	225	31	0.97	0	43	282	222	37	0.99	0	67	283	223	35	0.98	0
300	49	324	336	63	0.98	0	48	324	334	70	0.97	0	98	324	334	66	0.97	0
350	17	370	516	84	1.01	0	24	370	540	95	1.06	0	42	371	532	90	1.04	0
400	16	424	802	155	1.04	0	13	427	860	81	1.10	38	29	425	828	128	1.07	17
450	5	476	1080	127	1.00	0	6	465	1058	153	1.05	50	11	470	1068	135	1.02	27
500	2	523	1575	35	1.10	0	1	500	1300	-	1.04	0	3	515	1483	161	1.08	0
550	1	570	2075	-	1.12	0	-	-	-	-	-	-	1	570	2075	-	1.12	0
TOTAL	117						137						259					
MEAN		346	468	321	1.02			334	421	257	1.05			338	438	288	1.03	

Appendix 4. Summary of biological data by age for Arctic charr taken by angling in the Sylvia Grinnell River, 1977.

AGE (YR)	MALES							FEMALES							COMBINED					
		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
5	1	281	-	200	-	0.90	0	-	-	-	-	-	-	-	1	281	-	200	-	0.90	0
6	1	223	-	125	-	1.13	0	2	267	29.7	163	53	0.84	0	3	252	33.0	150	43	0.93	0
7	2	246	51.6	213	18	1.60	0	3	271	18.9	242	52	1.20	0	5	261	32.3	230	41	1.36	0
8	11	304	26.3	300	90	1.04	0	13	298	32.0	277	119	1.00	0	26	294	38.7	272	115	1.01	0
9	18	318	37.9	342	177	0.99	0	21	314	34.9	321	130	0.99	0	39	316	35.9	331	152	0.99	0
10	14	344	61.5	475	360	1.03	0	23	326	46.9	374	204	0.99	4	37	332	52.8	412	273	1.01	3
11	22	319	40.5	342	174	1.02	0	22	335	48.1	406	217	1.00	9	45	325	46.2	368	199	1.01	4
12	15	368	50.1	542	249	1.02	0	9	337	45.0	403	239	0.98	0	24	356	49.7	490	249	1.01	0
13	9	409	80.0	781	562	0.99	0	14	373	61.0	588	319	1.04	7	23	387	69.6	663	429	1.02	4
14	4	383	35.7	519	206	0.88	0	5	351	48.9	475	267	1.00	0	9	365	44.2	494	228	0.95	0
15	3	454	55.2	925	307	0.96	0	2	374	5.7	513	18	0.98	0	5	422	58.9	760	314	0.97	0
16	1	395	-	550	-	0.89	0	-	-	-	-	-	-	-	1	395	-	550	-	0.89	0
TOTAL	101							114							218						
MEAN		340	62	445	308	1.02			328	49.7	388	222	1.00			332	57.4	410	267	1.01	
MEAN AGE	10.5																				

Appendix 5. Summary of biological data by length interval for Arctic charr taken by experimental gillnets (38, 63, 89, 114, and 139 mm mesh size) in the Sylvia Grinnell River, 1976.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT
150	7	190	61	13	0.88	0	11	191	61	13	0.87	0	19	191	62	13	0.89	0
200	16	221	106	28	0.96	0	21	223	105	19	0.94	0	38	222	105	23	0.95	0
250	3	294	267	29	1.05	0	7	290	250	29	1.02	0	10	292	255	28	1.03	0
300	11	315	291	38	0.93	0	6	333	392	58	1.05	0	18	321	325	65	0.97	0
350	11	376	550	81	1.03	0	7	375	564	75	1.07	0	18	375	556	76	1.05	0
400	6	417	775	52	1.07	0	6	426	767	93	0.99	0	13	421	773	70	1.03	0
450	1	453	1150	-	1.24	0	-	-	-	-	-	-	1	453	1150	-	1.24	0
500	-	-	-	-	-	-	1	503	1400	-	1.10	0	1	503	1400	-	1.10	0
TOTAL	55						59						118					
MEAN		296	327	267	0.98			280	287	282	0.97			288	307	275	0.98	

Appendix 6. Summary of biological data by age for Arctic charr taken by experimental gillnets in the Sylvia Grinnell River, 1976.

AGE (YR)	MALES							FEMALES							COMBINED					
	N	LENGTH(MM) MEAN	LENGTH(MM) SD	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT	N	LENGTH(MM) MEAN	LENGTH(MM) SD	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT	N	LENGTH(MM) MEAN	LENGTH(MM) SD	WEIGHT(G) MEAN	WEIGHT(G) SD	K	% MAT
5	2	210	38.2	100	71	0.97	0	-	-	-	-	-	-	-	2	210	38.2	100	71	0.97	0
6	2	198	1.4	63	18	0.80	0	4	210	20.1	88	32	0.91	0	7	204	15.8	79	27	0.90	0
7	6	201	15.7	71	19	0.86	0	13	208	17.5	87	26	0.95	0	20	206	16.3	83	24	0.93	0
8	6	279	82.8	267	241	0.97	0	8	243	41.9	153	95	0.96	0	14	258	62.7	202	175	0.97	0
9	13	275	62.8	246	193	1.02	0	9	282	58.8	269	168	1.04	0	22	278	59.9	256	179	1.03	0
10	6	369	52.3	558	248	1.03	0	6	343	71.4	433	268	0.93	0	12	356	61.2	496	254	0.98	0
11	5	337	17.5	360	82	0.93	0	5	309	54.9	340	213	1.01	0	11	323	39.0	345	146	0.96	0
12	1	363	-	500	-	1.05	0	1	362	-	450	-	0.95	0	3	382	33.8	583	189	1.02	0
13	4	411	38.0	775	287	1.08	0	5	426	49.5	820	340	1.02	0	9	419	42.8	800	299	1.05	0
14	1	388	-	600	-	1.03	0	1	436	-	800	-	0.97	0	2	412	33.9	700	141	1.00	0
15	-	-	-	-	-	-	-	1	424	-	750	-	0.98	0	1	424	-	750	-	0.98	0
16	1	397	-	600	-	0.96	0	-	-	-	-	-	-	-	1	397	-	600	-	0.96	0
TOTAL	47							53							104						
MEAN		297	83	330	271	0.98			283	85.1	293	284	0.97			289	84.2	311	278	0.98	
MEAN AGE	9.2																				

Appendix 7. Summary of biological data by length interval for Arctic charr taken by experimental gillnets in the Sylvia Grinnell River, 1977.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT
150	1	186	75	-	1.17	0	2	183	75	0	1.22	0	3	184	75	0	1.20	0
200	2	230	100	0	0.82	0	7	223	93	19	0.84	0	10	224	95	16	0.84	0
250	7	282	251	60	1.11	0	4	290	275	35	1.13	0	11	285	260	52	1.12	0
300	36	328	374	58	1.05	0	38	322	376	75	1.12	0	74	325	375	67	1.09	0
350	37	370	600	121	1.17	0	28	377	618	97	1.15	7	65	373	608	111	1.16	3
400	27	420	865	120	1.17	0	18	421	860	133	1.15	22	45	421	863	124	1.16	9
450	13	475	1306	85	1.22	0	15	468	1212	209	1.17	60	28	472	1255	168	1.19	32
500	5	531	1775	87	1.19	40	3	514	1692	577	1.22	100	8	525	1744	318	1.20	63
TOTAL	128						115						244					
MEAN		377	679	388	1.13			365	628	387	1.13			371	652	388	1.13	

Appendix 8. Summary of biological data by age for Arctic charr taken by experimental gillnets in the Sylvia Grinnell River, 1977.

AGE (YR)	MALES							FEMALES							COMBINED					
	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT
6	2	278	130.1	350	389	1.20	0	3	195	21.4	83	14	1.13	0	5	228	80.7	190	243	1.16	0
7	1	297	-	350	-	1.34	0	3	253	29.3	175	109	1.00	0	5	256	33.6	195	120	1.05	0
8	4	316	64.3	463	309	1.24	0	8	278	52.0	244	136	0.99	0	12	291	56.5	317	222	1.07	0
9	10	341	50.5	450	248	1.04	0	7	329	35.9	418	162	1.12	0	17	336	44.2	437	211	1.08	0
10	28	372	60.1	658	320	1.16	0	21	354	36.9	537	191	1.16	5	49	364	51.8	606	276	1.16	2
11	19	365	53.5	601	337	1.14	0	16	363	57.6	589	336	1.12	13	35	364	54.6	596	332	1.13	6
12	22	380	48.9	658	347	1.13	0	13	380	70.4	769	579	1.20	23	35	380	56.8	699	442	1.16	9
13	20	393	62.6	745	436	1.10	0	12	384	47.6	665	246	1.13	8	32	389	56.8	715	374	1.11	3
14	5	403	49.8	810	317	1.18	0	12	435	31.5	935	257	1.12	33	17	426	39.0	899	272	1.14	24
15	2	522	37.5	1563	336	1.09	50	6	435	55.1	929	471	1.04	33	8	457	63.0	1088	510	1.06	38
16	3	486	62.6	1233	461	1.04	0	2	473	17.0	1288	265	1.21	50	5	481	45.6	1255	353	1.11	20
17	2	439	4.9	900	0	1.07	0	-	-	-	-	-	-	-	2	439	4.9	900	0	1.07	0
18	1	520	-	1800	-	1.28	100	-	-	-	-	-	-	-	1	520	-	1800	-	1.28	100
20	-	-	-	-	-	-	-	1	485	-	1300	-	1.14	100	1	485	-	1300	-	1.14	100
TOTAL	119							104							224						
MEAN		378	66	682	391	1.13			365	72.9	625	392	1.12			371	70.1	653	392	1.13	
MEAN AGE	11.3																				

Appendix 9. Summary of biological data by length interval for Arctic charr taken by subsistence gillnets (89 mm mesh size) in the Sylvia Grinnell River, 1977.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	WEIGHT(G) MEAN	SD	K	% MAT
200	1	246	175	-	1.18	0	1	200	100	-	1.25	0	2	223	138	53	1.21	0
250	2	271	213	18	1.07	0	3	278	250	43	1.16	0	6	279	238	34	1.09	0
300	4	311	338	60	1.11	0	1	332	400	-	1.09	0	7	316	336	56	1.06	0
350	9	383	650	59	1.15	0	5	377	625	53	1.18	0	14	381	641	56	1.16	0
400	5	415	805	122	1.12	0	3	440	958	80	1.13	100	12	426	860	115	1.11	25
450	4	476	1125	65	1.05	0	1	458	1000	-	1.04	100	8	468	1094	91	1.07	13
500	1	530	1550	-	1.04	100	1	542	1850	-	1.16	100	4	527	1700	173	1.16	50
TOTAL	26						15						53					
MEAN		384	688	341	1.11			371	673	440	1.15			389	734	410	1.12	

Appendix 10. Summary of biological data by age for Arctic charr taken by subsistence gillnets in the Sylvia Grinnell River, 1977.

AGE (YR)	MALES							FEMALES							COMBINED						
	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT	N	LENGTH(MM) MEAN	SD	WEIGHT(G) MEAN	SD	K	% MAT
7	3	276	31.6	233	80	1.09	0	-	-	-	-	-	-	-	3	276	31.6	233	80	1.09	0
8	1	480	-	1100	-	0.99	0	2	270	7.1	225	0	1.15	0	3	340	121.3	517	505	1.10	0
9	2	286	23.3	263	53	1.12	0	1	359	-	625	-	1.35	0	3	310	45.5	383	213	1.20	0
10	4	378	37.6	619	133	1.14	0	3	374	72.4	642	317	1.16	33	7	376	49.6	629	206	1.15	14
11	6	405	73.7	800	431	1.11	17	1	354	-	575	-	1.30	0	7	398	70.1	768	403	1.14	14
12	3	433	47.4	917	208	1.13	0	2	449	13.4	1025	35	1.14	100	5	439	35.1	960	160	1.13	40
13	-	-	-	-	-	-	-	2	388	2.8	613	53	1.05	0	2	388	2.8	613	53	1.05	0
14	1	385	-	650	-	1.14	0	-	-	-	-	-	-	-	1	385	-	650	-	1.14	0
16	-	-	-	-	-	-	-	1	542	-	1850	-	1.16	100	1	542	-	1850	-	1.16	100
18	1	404	-	725	-	1.10	0	-	-	-	-	-	-	-	1	404	-	725	-	1.10	0
20	-	-	-	-	-	-	-	1	448	-	900	-	1.00	100	1	448	-	900	-	1.00	100
TOTAL	21							13							34						
MEAN		377	75	654	351	1.11			387	79.5	738	434	1.15			381	75.5	686	381	1.13	
MEAN AGE	11.0																				

Appendix 11. Summary of biological data by length interval for Arctic charr taken by snagging in the Sylvia Grinnell River, 1977.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%		LENGTH(MM)	WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
150	-	-	-	-	-	-	1	195	50	-	0.67	0	5	189	65	14	0.97	0
200	1	220	125	-	1.17	0	1	237	125	-	0.94	0	16	228	120	28	1.00	0
250	4	290	231	13	0.95	0	7	284	236	50	1.02	0	40	278	218	37	1.01	0
300	31	327	348	62	0.98	0	13	325	356	59	1.03	0	146	326	355	60	1.02	0
350	8	367	531	72	1.07	0	11	371	518	85	1.01	0	69	371	541	70	1.06	0
400	2	414	738	124	1.04	0	1	412	725	-	1.04	0	12	418	758	91	1.04	0
450	-	-	-	-	-	-	-	-	-	-	-	-	3	472	1158	153	1.10	0
500	-	-	-	-	-	-	-	-	-	-	-	-	1	508	1500	-	1.14	0
TOTAL	46						34						292					
MEAN		332	382	133	1.00			328	379	154	1.01			328	391	188	1.03	

Appendix 12. Summary of biological data by age for Arctic charr taken by snagging in the Sylvia Grinnell River, 1977.

AGE (YR)	MALES							FEMALES							COMBINED						
		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
6	-	-	-	-	-	-	-	2	246	72.1	188	194	0.96	0	2	246	72.1	188	194	0.96	0
7	1	220	-	125	-	1.17	0	4	307	32.1	306	88	1.04	0	5	289	47.7	270	111	1.07	0
8	4	322	24.1	325	89	0.95	0	-	-	-	-	-	-	-	4	322	24.1	325	89	0.95	0
9	10	342	36.4	425	152	1.03	0	8	305	28.1	284	82	0.98	0	18	325	37.2	363	142	1.01	0
10	6	323	19.0	342	97	0.99	0	7	354	19.4	479	97	1.07	0	13	340	24.2	415	117	1.03	0
11	8	322	21.0	331	66	0.98	0	3	375	47.6	567	213	1.04	0	11	336	37.0	395	156	1.00	0
12	7	349	26.1	432	104	1.00	0	5	352	21.9	435	74	0.99	0	12	350	23.5	433	89	1.00	0
13	-	-	-	-	-	-	-	1	375	-	525	-	1.00	0	1	375	-	525	-	1.00	0
14	1	363	-	550	-	1.15	0	-	-	-	-	-	-	-	1	363	-	550	-	1.15	0
15	2	386	50.9	638	265	1.07	0	-	-	-	-	-	-	-	2	386	50.9	638	265	1.07	0
16	-	-	-	-	-	-	-	1	398	-	575	-	0.91	0	1	398	-	575	-	0.91	0
TOTAL	39							31							70						
MEAN		334	36	390	140	1.01			332	45.8	394	151	1.01			333	40.3	392	144	1.01	
MEAN AGE	10.1																				

Appendix 13. Description of the relative stages of maturity of Arctic charr based on gross examination of the gonads.

Maturity (Male and Female)	Description of Gonads
Immature	Virgin fish; gonads thin and threadlike, often incomplete.
Maturing	Virgin or non-virgin fish not spawning in the current year; gonads full length, firm; eggs small; gonads partially fill body cavity.
Mature	Fish spawning in current year; gonads full size, filling body cavity; eggs prominent, full size.
Ripe	Mature fish in spawning condition; eggs translucent; milt or eggs expelled under slight pressure.
Spent	Mature fish, completed spawning; gonads collapsed with ruptured blood vessels prominent; residual eggs present.

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